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10/523850
BT01 Rec'd PCT/PTO 07 FEB 2005

METHOD FOR CUTTING A CONTINUOUS GLASS SHEET DURING THE PRODUCTION OF FLAT GLASS

The present invention relates to a method for cutting a continuous glass sheet during the production of flat glass with an inhomogeneous thickness distribution across its width by moving a cutting tool at an angle to the direction of travel across the width of the glass sheet with a cutting force predetermined by a controller, producing a fissure, then mechanically breaking the glass sheet along the fissure.

Flat glass, in contrast to hollow glass ware, is understood to mean all glasses manufactured with a flat shape, independent of the production technology used.

In addition to the float glass process, various down-draw methods are used today to manufacture flat glasses, such as overflow fusion, redraw and nozzle processes, and various up-draw processes, such as the Fourcault or Asahi process, for shaping. The glass is shaped into a glass sheet while it is still in a viscous state due to the high operating temperatures. The glass sheet is then cooled, whereby the temperature of the glass passes the two annealing points and then cools to essentially room temperature.

The continuously-produced glass sheet is subsequently cut into panels in various final and intermediate formats in a cross-cutting machine at an angle to the direction of flow. To this end, a mechanical small cutting wheel or thermally induced, e.g., using a laser beam, strain states are typically used to produce a rupture in the glass surface, i.e., a crack or notch, which is continued across the width of the sheet; subsequently, the microscopically small fissure that results or was continued across the width of the sheet is driven through, using external forces, until it reaches the other side and the glass sheet is divided into separate pieces.

During the shaping of the glass sheet, a somewhat different thickness distribution usually forms on the edges than in the center and/or on the subsequent net usable surface area due to surface forces, temperature and viscosity gradients and as a result of mechanical shaping and conveyance tools, such as rollers. The thickness can become thinner than the net surface area, as is the case with the nozzle process using the down-draw method, or thicker than the net surface area, as is the case with the float glass process. The edge region on either side of the glass sheet is referred to as the border region.

This inhomogeneous thickness distribution across the width of the glass sheet becomes noticeable during production of thin glass (< 3 mm) in particular.

During cross-cutting, depending on the system, a small cutting wheel is typically moved across the glass surface with pressure, with the objective of mechanically creating a notch (fissure) across the entire width of the glass sheet. The glass sheet is not divided into separate pieces yet, however. The glass sheet is broken at the fissured point in a further working step.

With the known systems, the cutting force with which the cross-cutting of the particular glass sheet is carried out is set at a constant value by the operator of the cross-cutting machine in the associated electrical controller. If the cross-cutting procedure is then carried out using a cutting force with a constant setting, the following two states result:

1. The cutting force is set at a level that enables an adequate surface notch to be created in the thicker regions, and breaking can then be carried out successfully. In the thin regions of the glass sheet, the glass is acted upon with excessive cutting force. As a result, the glass is broken into pieces in an uncontrolled manner, before the actual breaking process can be carried out.

2. The cutting force is set at a level that enables an adequate surface notch to be created in the thin regions, and the glass remains intact. An inadequate notch is created in the thicker regions and, above all, the roller tracks, however. In the subsequent breaking procedure, the borders are therefore either not broken or are broken in an uncontrolled manner.

In either case, as a result of the uncontrolled breaking, the net glass separated from the border region cannot be used, or it can be used only if additional work is performed.

The same applies for cross-cutting using thermally induced strain states, e.g., using a laser beam with a constant output, combined with a mechanical starting point of a fracture created using a cutting tool.

The object of the present invention is to carry out the method, described initially, for cutting a glass sheet with regard for the cutting force applied such that the border and net region are fissured enough to perform the breaking procedure correctly, while preventing the glass sheet from separating into parts prematurely.

According to the present invention, the means for attaining the goal of this object with a method for cutting a continuous glass sheet during the production of flat glass with an inhomogeneous thickness distribution across its width by moving a cutting tool at an angle to the direction of travel across the width of the glass sheet with a cutting force predetermined by a controller, producing a fissure, then mechanically breaking the glass sheet along the fissure are achieved by the fact that the cutting force, adapted to the glass thickness, is actively specified by the controller.

The present invention is therefore based on a method for applying a cutting force adapted to the glass thickness by designing the actively specified force of the cutting tool acting on the glass sheet during cross cutting not to be constant across the width of the sheet, but variable.

In other words:

According to the present invention, the cutting force is actively varied as a function of the position coordinates of the contact point of the cutting tool at an angle to the direction of flow of the glass sheet. A stronger cutting force is applied in the edge regions (borders), for example, of a floated glass sheet with greater glass thickness, and, in the net region of the floated glass sheet, a lesser cutting force adjusted for the lower glass thickness is applied. The distribution of the cutting force is reciprocal thereto in the case of glass sheets with thinner borders produced using the down-draw method.

Patent US 3,282,140 A describes a method for cutting a continuous glass sheet during the production of flat glass by moving a cutting tool across the width of the glass sheet at an angle to the direction of travel, producing a fissure, then mechanically breaking the glass sheet along the fissure. The cutting tool is thereby retained in a holder using a spring or a pneumatic cylinder or a combination of both such that the cutting tools bears with elastic resilience on the glass sheet surface with a predetermined amount of pressure. The cutting force is not actively varied by the spring and/or the pneumatic cylinder as it traverses the glass sheet. At most, the cutting force can be changed as a function of the distance between the glass sheet surface and the cutting tool with consideration for the spring force constants and/or the characteristic curve of the pneumatic cylinder. With the method according to the present invention, the cutting force is not predetermined passively using a spring or a pneumatic cylinder. Instead, it is predetermined electrically using a controller, and it is actively influenced by it, i.e., as a function of the technological circumstances and the inputs made by the

system operators. This approach makes it possible to adapt the cutting force during on-going production to the technological circumstances while making the cut or between cuts without the need to mechanically convert the cutting device, because the mechanical properties of a spring and/or the characteristic curve of a pneumatic cylinder limit the range of variation of the cutting force.

Similar cutting systems are described in GB 1 485 000 A and DD 115 644 A, the cutting heads of which are configured such that different distances between the glass sheet surface and the cutting head, caused by surface irregularities or fluctuations in glass thickness, for example, are corrected by a spring-loaded shaft. The disadvantages are the same as those described above for US 3,282,140. Neither publication includes mention of an active control of the cutting force.

According to a further development of the present invention, a method is provided with which the position of the cutting tool is detected continuously during its cross-cutting motion and, depending on the position of the cutting tool, the controller applies an appropriately adapted cutting force in the region of the glass sheet with constant glass thickness and, in the regions with greater or smaller glass thickness, the controller applies a cutting force that is increased or reduced accordingly. It is simplest when the position-dependent switchover points for the cutting force are predetermined in a fixed manner in the controller, e.g., based on experiential values measured across the width of the border regions and the change in glass thickness in these regions compared with the net region of the glass sheet.

According to a further development of the present invention, the cutting force used in the method, which is adapted to the glass thickness, is predetermined in a fixed manner in the controller as a function of an initial measurement of the thickness distribution. Very satisfactory results are obtained with a method of this

type, since, based on experience, the distribution of the glass thickness does not vary significantly over the course of the glass sheet.

Optimized implementation of the method is given when the glass thickness is detected continuously by the sensors during cross-cutting and the cutting force is automatically adjusted as a function thereof. When this method is implemented in this manner using a controller, changes in glass thickness distribution are also detected over the course of the glass sheet.

The method according to the present invention is capable of being carried out such that the fissure is produced mechanically using a small cutting wheel, and the cutting force is predetermined by the force of the small cutting wheel on the glass sheet.

As an alternative, the fissure can also be produced by inducing a thermomechanical strain, and the cutting force can be adjusted via the output of a heat source. A laser beam is typically used to produce the thermomechanical strain.

The present invention is described in greater detail with reference to an exemplary embodiment shown in the drawing.

Figure 1 shows a top view of the cross-cutting region for cutting a continuous glass sheet,

Figure 2 shows a top, sectional view of the cross cutter in Figure 1, combined with a real, inhomogeneous thickness distribution of thickness "d" of glass sheet in Part A, and the associated distribution of cutting force "F" in Part B, and

<u>Figure 3</u> shows the layout of a controller for adjusting the cutting force as a function of glass thickness.

Figure 1 shows a glass sheet 1 that is drawn continuously in the direction of the arrow, and that is cut at an angle to the direction of drawing while the sheet is moving, using a cross cutter 2. To this end, the cross cutter is located at a certain angle to the direction of flow.

A system of this type is known per se, e.g., from patent US 3,282,140 referenced initially.

As also shown in Figure 2, the cross cutter is composed of a crossmember 3 extending transversely across the width of the glass sheet, on which said crossmember a cutting head 4 is retained in a longitudinally displaceable manner. A drive arrangement 5 is provided to move the cutting head, and a home-position sensor 6 detects when the cutting motion starts. Cutting head 4 includes, in a known manner, a small cutting wheel 7 that is pressed against glass sheet 1 with a predetermined amount of force and produces a fissure at an angle to the width of the sheet when the cutting head moves. The glass sheet is not separated into pieces yet. The glass sheet is broken at the fissured point in a further working step.

As described initially, the thickness distribution of glass sheet 1 is not homogeneous along the cross-cut to be carried out, however, due to the method used. When flat glass is produced in float systems, the glass thickness in the outer regions, the “borders”, i.e., to the left and right of the net and/or good glass, is usually greater than within the net glass sheet. This real, inhomogeneous course of thickness is shown in Part A of Figure 2. If the cross-cutting procedure according to the related art is carried out using a cutting force with a constant setting, the following two conditions result:

1. The cutting force is set at a level that enables an adequate surface notch to be produced in the edge regions, and breaking can then be carried out successfully. In the net region of the glass sheet, however, the glass is acted upon with excessive cutting force. As a result, the glass is broken into pieces in an uncontrolled manner, before the actual breaking process can be carried out.

2. The cutting force is set at a level that enables an adequate surface notch to be created in the net region, and the glass remains intact. An inadequate notch is created in the edge regions and, above all, the roller tracks, however. As a result, the borders are therefore either not broken or are broken in an uncontrolled manner in the subsequent breaking procedure. To prevent these disadvantages, cutting force F is varied—as also shown in Part A of Figure 2—as a function of the position coordinates of the contact point of small cutting wheel 7 on the glass sheet in a stroke at a right angle to the direction of flow of the glass sheet. A stronger cutting force is applied in the edge regions having greater glass thickness, and a lesser cutting force is applied in the net region.

With the exemplary embodiment of the present invention according to Figure 2, two switchover points are provided that are predetermined in a fixed manner by a controller. The cutting force adapted to the glass thickness is set in a fixed manner as a function of an initial measurement of the thickness distribution.

A method is also feasible, however, with which the glass thickness is detected continuously during cross cutting and the cutting force is automatically adjusted as a function thereof.

Figure 3 shows an exemplary embodiment of a controller for adjusting the cutting force as a function of glass thickness. The controller includes a control computer

8, in which operator inputs such as switchover points and cutting forces are entered. It includes a digital input that is connected with home-position sensor 6. It also includes an analog output that is connected via a power part 9 with stage 10, which symbolizes drive 5 for the cutting head, and the stage in cutting head 4 for adjusting the cutting force. The control computer is further connected with two stages 11, which are connected with position sensors on the crossmember, allowing the control computer to always know the position of the cutting head and, therefore, small cutting wheel 7, and enabling it to carry out appropriate measures in accordance with the operator inputs. If the position of switchover points shown in Figure 2A is entered, for example, the switchover to a cutting force—which was also set in advance—takes place automatically as a function of the signals of stage 11.

Another advantage of the method according to the present invention is that only a minimal change need be made to the existing cutting device, since existing sensors and triggering devices can be used.